



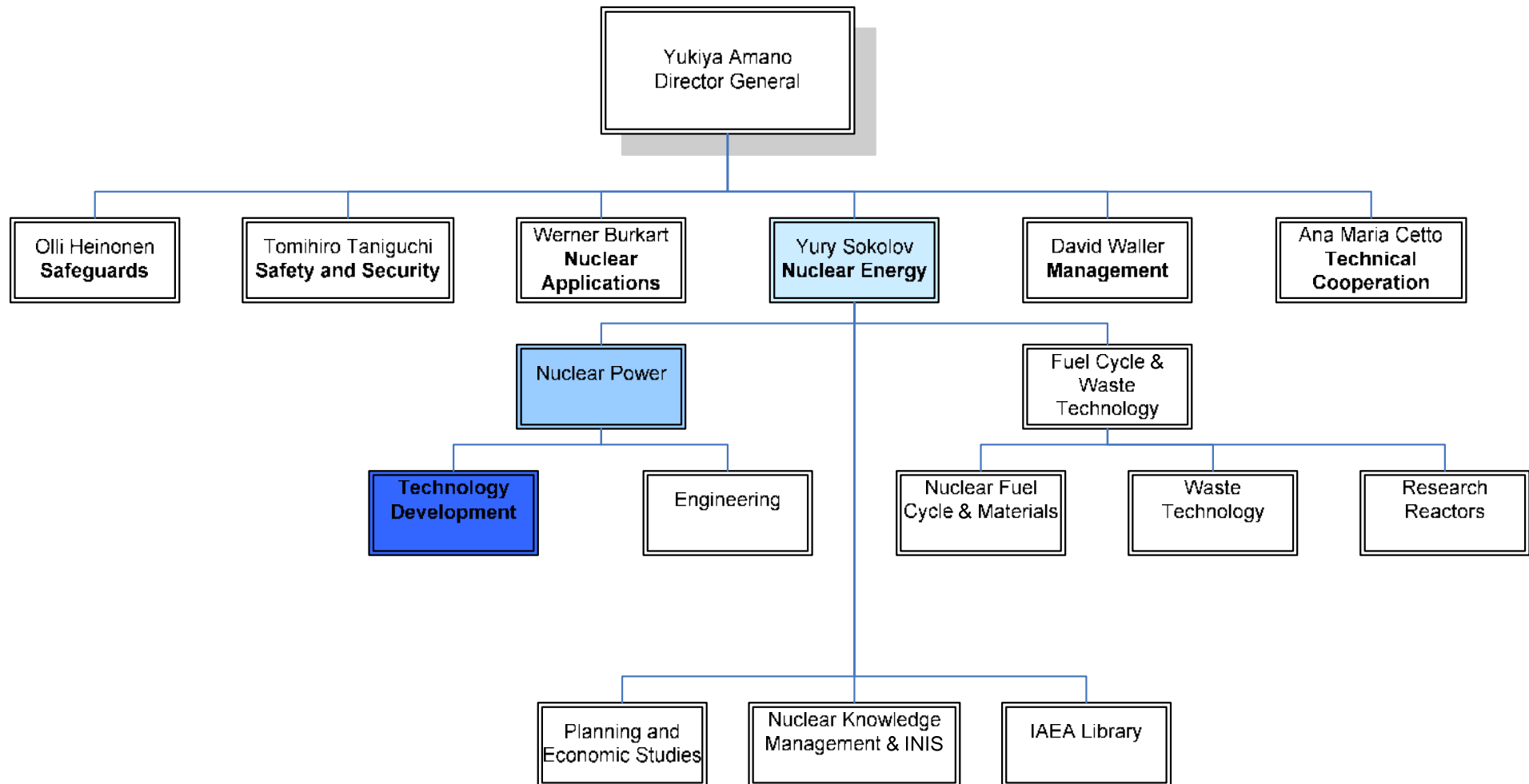
Overview of IAEA Project on Technology Advances in Water Cooled Reactors

Sama BILBAO Y LEON
S.Bilbao@iaea.org

Jong Ho CHOI
J.H.Choi@iaea.org

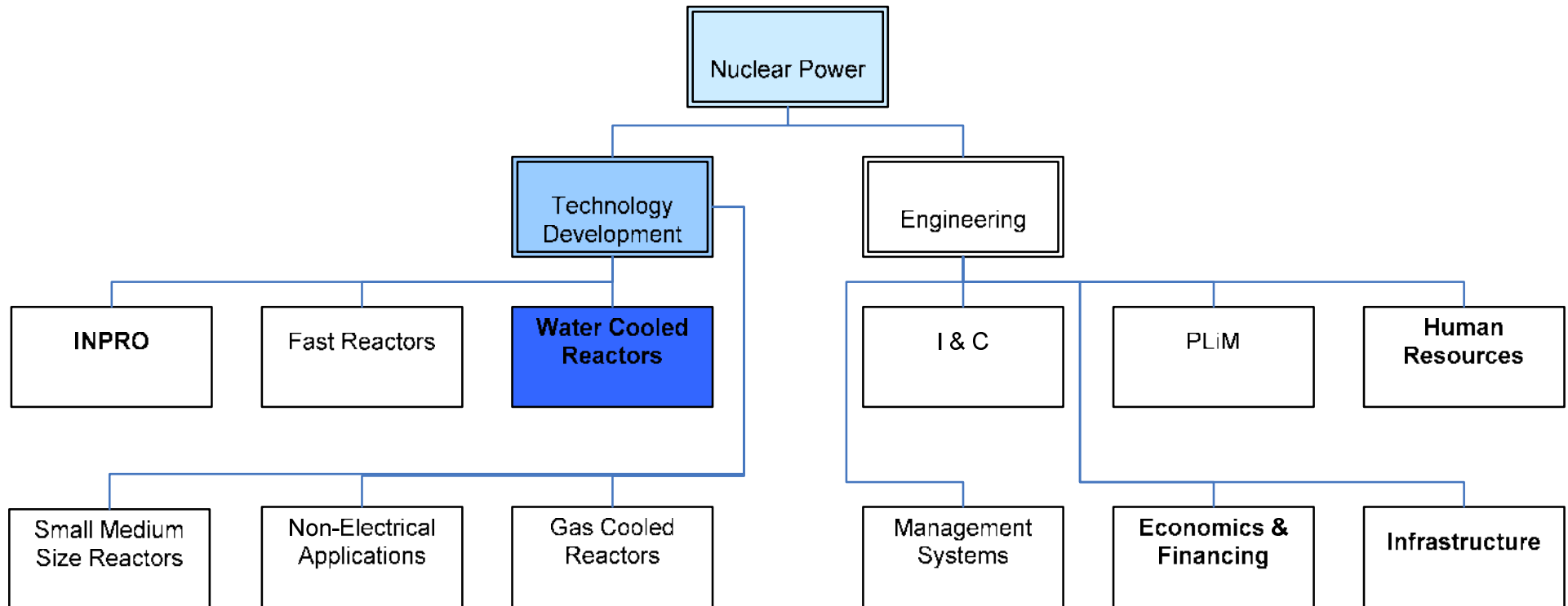
Division of Nuclear Power
IAEA

IAEA Organization



Nuclear Energy Department

Nuclear Power Division



Water Cooled Reactors Group

The WCR Group **monitors** worldwide activities taking place in the area of water cooled reactor technology development, **facilitates** the international **exchange** and identification of challenges and opportunities in this area, and **fosters** the international **collaboration** towards addressing of the challenges and capitalizing on the opportunities



What we do to achieve our vision

- Continuously monitor worldwide activities on technology development for WCRs
- Facilitate exchange of information among IAEA Member States on technology development for WCRs
- Foster international collaboration on technology development for WCRs
- Support near term development and deployment of nuclear programs for both emerging and existing countries in WCR technology
- Provide technology training in WCR technology



Areas of Focus: Development and Deployment of New Water Cooled Reactors

- Design and technologies for advanced WCRs;
- Economics, performance and safety for advanced WCRs;
- Advanced fuel cycles and fuel options for advanced WCRs;
- Infrastructure specific to the development and deployment of WCRs.



Advisory Group

- Two Technical Working Groups (TWG)
 - Advanced Technologies for Light Water Reactors (LWRs)
 - Advanced Technologies for Heavy Water Reactors (HWRs)
- Role: Advise and make recommendations on activities for the next 2 budget cycles that will support the advance of WCRs and their development and deployment in the next 50 years.





2009 Recommendations

2009 Recommendations

- Special Work Group on “Future Role of WCRs in the 21st Century” (May 2009)
 - WCRs are the only realistic technology for the beginning of 21st century
 - Mature technology → take advantage of experience
 - Bridge technology to Gen IV designs
 - Need for WCRs to evolve and adapt to future needs
 - Thrive not just survive
 - WCRs to be able to provide a mix of products (electricity, process heat, water, hydrogen, transportation)
 - Challenges
 - Economics
 - Fissionable Resources
 - Development of Advanced Materials
 - Waste Management



2009 Recommendations

- Joint Meeting of TWG-LWR and TWG-HWR (July 2009)
 - New Challenges
 - Help clarify the costs of new WCRs
 - Materials reliability for 60+ plant life designs
 - Advanced computational tools (CFD codes, simulators)
 - Fuel issues (5% enrichment limit, high conversion rates, Thorium)
 - Deployment issues (construction, modularization, standardization)
 - New Channels
 - Better use of the web
 - Better use of DBs
 - Use of online/virtual training
 - Course development
 - Virtual meetings
 - Team approach: capitalize on the strengths of team members





WCRs Group Activities since last TWG Meeting

What we do to achieve our vision

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1. Continuously monitor worldwide activities in the area of WCR technology development

Status Reports on Advanced Reactor Designs

- Status of Small Reactor Designs without On-site Refuelling, TECDOC-1536, IAEA (2007).
- Status of innovative small and medium sized reactor designs: 2005: Reactors with conventional refuelling schemes, TECDOC-1485, IAEA (2006).
- Status of Advanced Light Water Cooled Reactor Designs: 2004, IAEA-TECDOC-1391, IAEA, Vienna (2004).
- HWRs: Status and Projected Development, TRS-407, IAEA, Vienna (2002).
- Current status and future development of modular high temperature gas cooled reactor technology, TECDOC-1198, IAEA (2001).
- Status of Liquid Metal Cooled Fast Reactor Technology, IAEA-TECDOC-1083, IAEA, Vienna (1999).
- **ARIS: Advanced Reactors Information System**



IAEA Status Reports

ARIS-Status Report for Advanced Nuclear Reactor Designs - Microsoft Internet Explorer provided by IAEA

http://aris.iaea.org/ARIS/sonar.cgi

File Edit View Favorites Tools Help

ARIS-Status Report for Advanced Nuclear Reactor De...

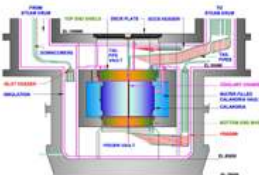
IAEA.org International Atomic Energy Agency

ARIS Advanced Reactors Information System

About IAEA ARIS home Browse

You are in: ARIS » ARIS home

Welcome to the IAEA ARIS



The data stored in ARIS is compiled from reactor design/concept, and harmonized depth of the reactor descriptions includes reports on nuclear steam system, and waste management, as well as significant change on a specific design.

Questions? Email us at [ARIS at iaea.org](mailto:ARIS@iaea.org)

About IAEA ARIS home Browse Search Feedback About us

You are in: ARIS » Browse

Browse reports of reactor designs

On this page you can view reports of all the reactor designs input in our database. The filter above the overview allows you to restrict the list to criteria of your choice. A detailed report can be accessed from each row of the list.

▼ Hide filter

Filter the records Apply filter Reset filter (select all records)

Full name * Acronym * Designer

Reactor type Coolant Moderator Neutron spectrum Non-electric applications

ID Thermal capacity (MWth) Electrical capacity (MWe) Licensing status *

Min value Max value Min value Max value Min value Max value


* The search is not case sensitive and can be performed on partial input.

List of reports on reactor designs - Selected: 1 / Total: 1

Page: 1 Records per page: 10 Update

ID	Full name	Acronym	Reactor type	Coolant	Moderator	Neutron spectrum	Thermal capacity (MWth)	Electrical capacity (MWe)	Licensing status	Non-electric applications	Designer	View report
1

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 2002



ARIS: Advanced Reactors Information System

- Web-accessible advanced reactor database that provides balanced and up-to-date comprehensive descriptions about the various advanced nuclear reactor designs
- All reactor designs: LWR, HWR, FR, GCR, SMR
- Allows sorting and filtering the information
- Technical Descriptions:
 - Provided by the Vendors/Designer Organizations
 - Reviewed by IAEA for balance and consistency
- Thank you for TWG support!



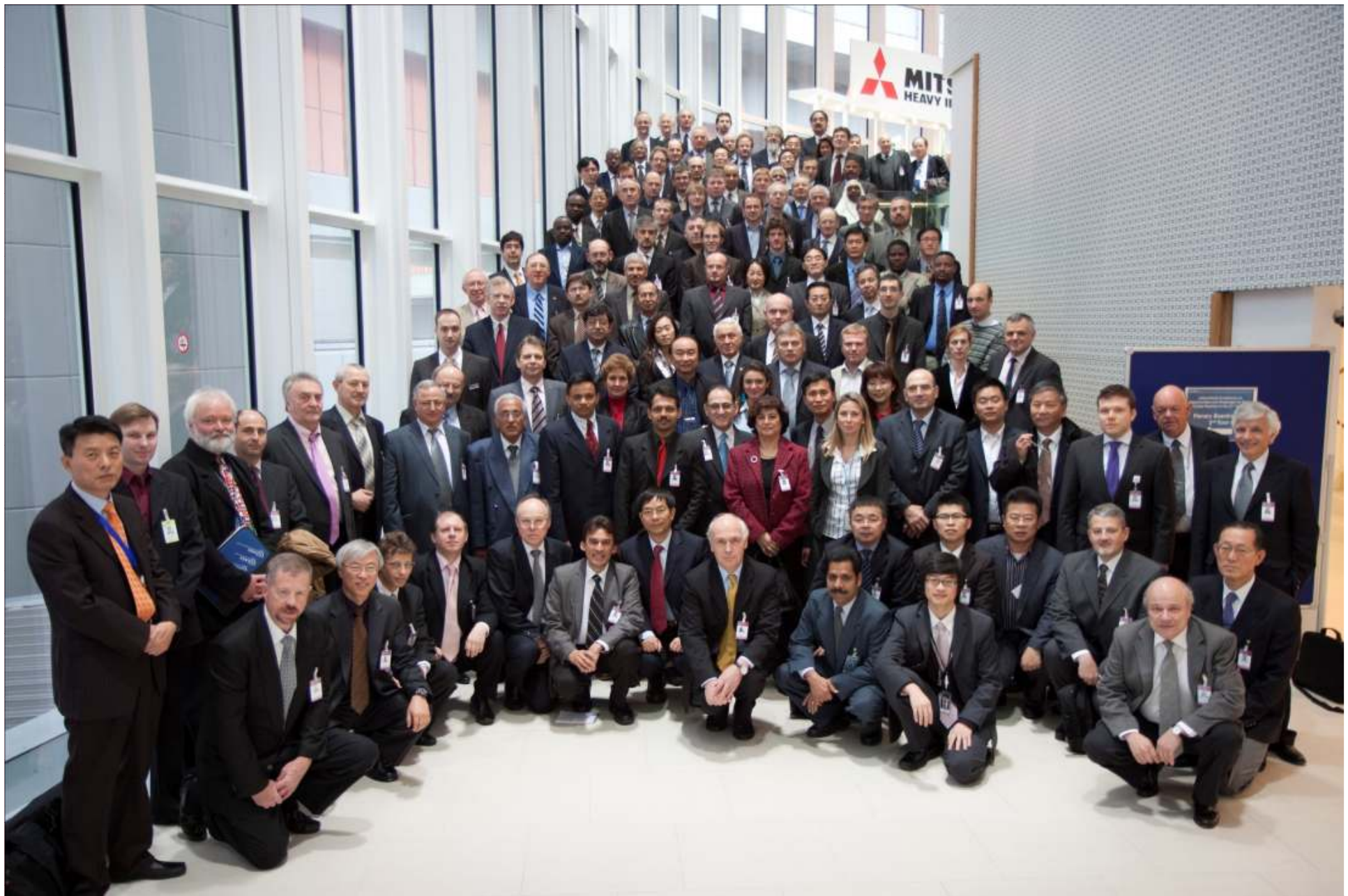


2. Facilitate exchange of information among MSs on technology development for WCRs

Information Exchange

- IAEA International Conference on Opportunities and Challenges for Water Cooled Reactors in 21st Century (October 27-30, 2009)
- Technical Meeting on “Improved Pellets and Advanced Fuel Designs for WCRs”(November 23-26, 2009)
- Technical Meeting on “Heat transfer, thermal-hydraulics and system design for supercritical pressure water cooled reactors” (July 5-8, 2010)
- Workshop on “Best Practices in HWR Operation” (April 12-14, 2011)
- Web-based database THERPRO “Database of Thermo-physical Properties of Materials for Advanced Nuclear Reactors” (<http://therpro.iaea.org>) (November 1-5, 2010)
- International Collaborative Assessment (ICA) on “Role of HWRs in the Efficient Utilization of Fissionable Resources
- Technical Meeting on “Application of CFD Codes for WCR Design” (December 14-16, 2010)





<http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=35251>

Technical Meeting “Improved Pellets and Advanced Fuel Designs for WCRs”

- November 23-26, 2009, Villigen, Switzerland



- Proceedings in publications review process

<http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=35292>



Technical Meeting on Heat transfer, thermal-hydraulics and system design for supercritical pressure water cooled reactors



<http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID= 38683>

Good Practices in HWR Operation

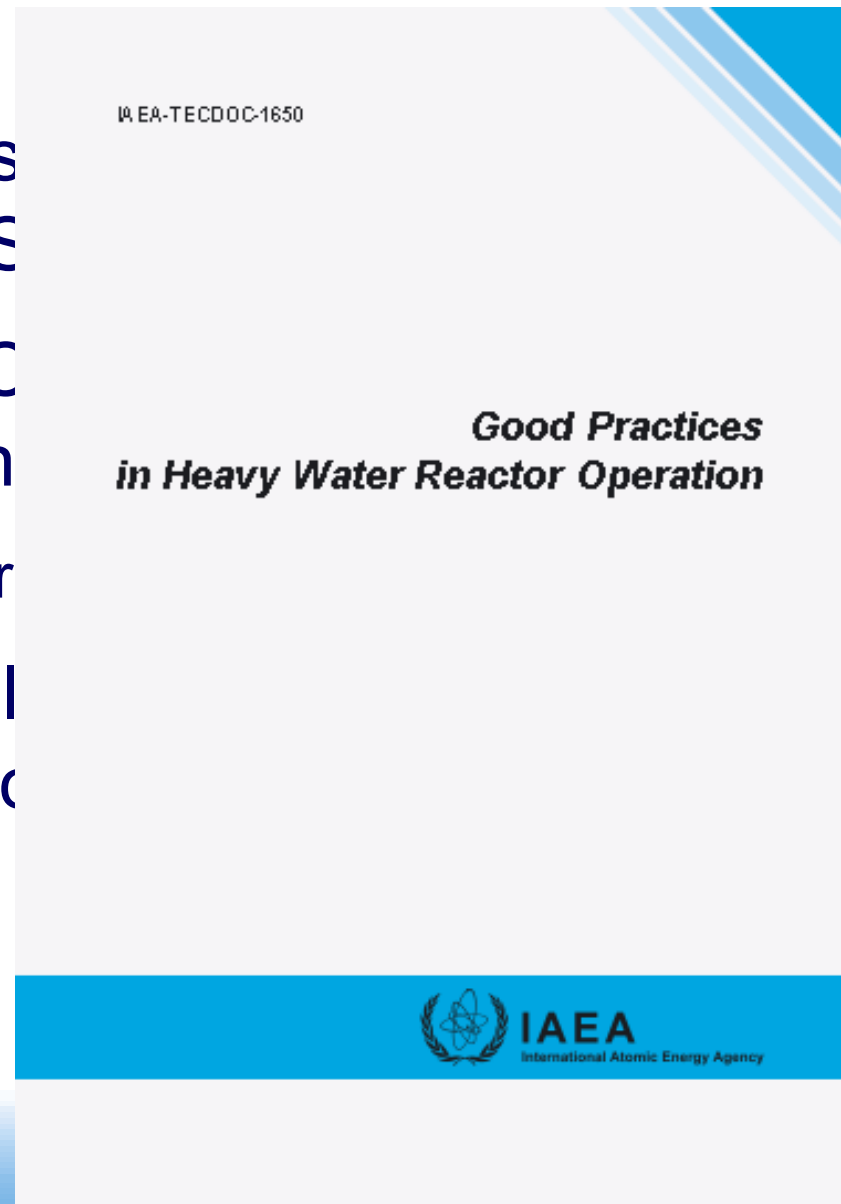
- AECL hosts workshop on 16-19 September
- IAEA-TECDOC-1650
Good Practices in Heavy Water Reactor Operation
– Summary of the 1st workshop
- KHNP will host the 2nd workshop in the Rep. of Korea

Toronto, Canada

Good Practices in HWR

1st workshop

Gyeongju,



International Atomic Energy Agency



THERPRO DB

- Database of Thermo-physical Properties of Materials for Advanced Nuclear Reactors” (<http://therpro.iaea.org>)
- Recommendations of May 5-7, 2009 meeting:
 - Creation of a THERPRO Advisory Work Group
 - Consolidate all IAEA data on thermophysical properties of materials into a single DB
 - Organization of periodic topical meetings in the area of thermophysical properties
 - Supported by TWG-FR and INPRO COOL CP
- Refurbishment Status:
 - Financial support of Ministry of Education, Science and Technology of the Korean government from September 2009 to August 2011
 - Hardware upgrade completed – February 2010
 - Software upgrade to be completed – August 2010
 - THERPRO Re-release by IAEA GC 2010
- Meeting on November 1-5, 2010





3. Foster international collaboration on technology development for WCRs

Collaboration in Technology Development

- **Coordinated Research Projects (CRP)**
 - CRP on Intercomparison of Techniques for Inspection and Diagnostics of HWR Pressure Tubes **(Completed)**
 - CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems that Utilize Natural Circulation **(Completed)**
 - CRP on Heat Transfer Behaviour and Thermo-hydraulics Code Testing for Super-Critical Water-Cooled Reactors (SCWRs)
 - CRP on Benchmarking Severe Accident Computer Codes for Heavy water Reactor Applications
 - CRP on Development of Advanced Methodologies for Substantiation of Passive System Performance in Innovative Reactor Designs
- **International Collaborative Standard Problems (ICSP)**
 - ICSP on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Containment and Primary System during Accidents
 - ICSP on Comparison of HWR Thermal-hydraulic Code Predictions with SBLOCA Experimental Data



CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems (1)

- **Specific Objectives**

- establish the status of knowledge: reactor start-up & operation; passive system initiation & operation; flow stability, 3-D effects and scaling laws
- investigate phenomena influencing reliability of passive NC systems
- review experimental databases for the phenomena
- examine the ability of computer codes to predict NC and related phenomena
- apply methodologies for examining the reliability of passive systems

- **Participants (16)**

- | | |
|------------------------------|-------------------------------------|
| – CNEA, Bariloche, Argentina | – KAERI, Rep. of Korea |
| – CEA, France | – Hidropress, Russian Federation |
| – FZ Dresden, Germany | – University of Valencia, Spain |
| – BARC, India | – PSI, Switzerland |
| – Univ. of Pisa, Italy | – Idaho State University, USA |
| – ENEA, Italy | – Oregon State University, USA |
| – IVS, Slovakia | – Purdue University, USA |
| – JAEA, Japan | – European Commission, JRC - Petten |



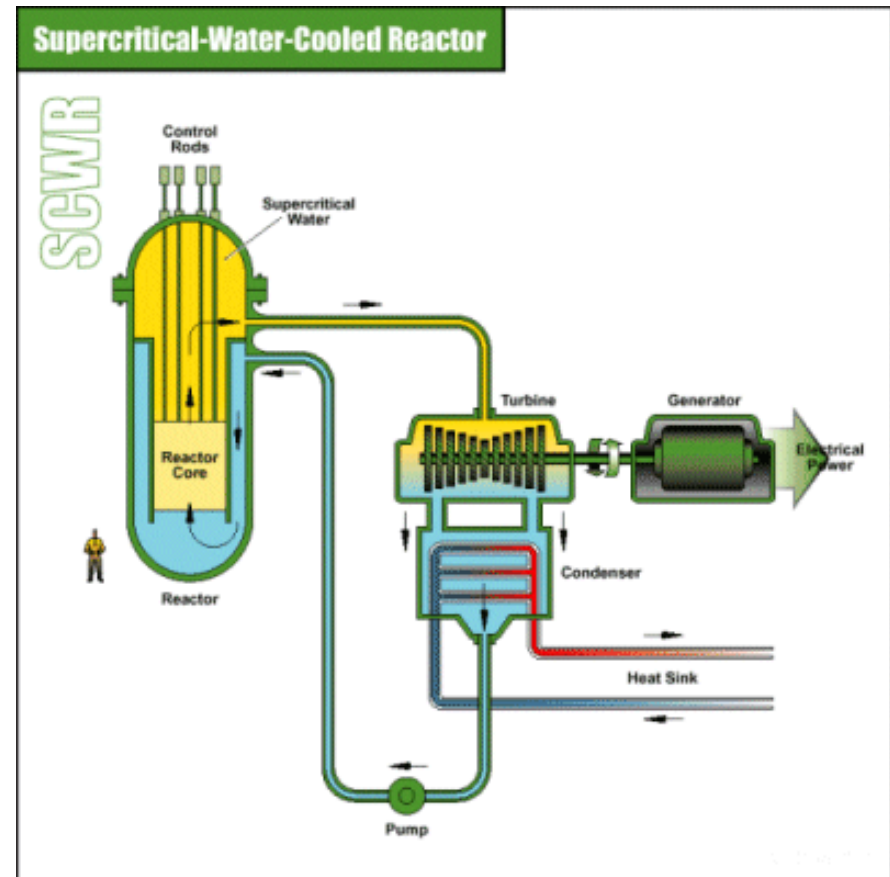
CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems (2)

- **Document Publication**
 - TECDOC-1474, “Natural Circulation in Water Cooled Nuclear Power Plants”, November 2005
 - TECDOC-1624, “Passive Safety Systems and Natural Circulation in Water Cooled Nuclear Power Plants”, November 2009
 - TECDOC-XXXX, “Natural Circulation Phenomena and Modelling for Advanced Water Cooled Reactors”, in publication
- **Training Course on Natural Circulation Phenomena and Passive Safety Systems in Advanced Water Cooled Reactors**
- **The CRP was closed officially in 2009**

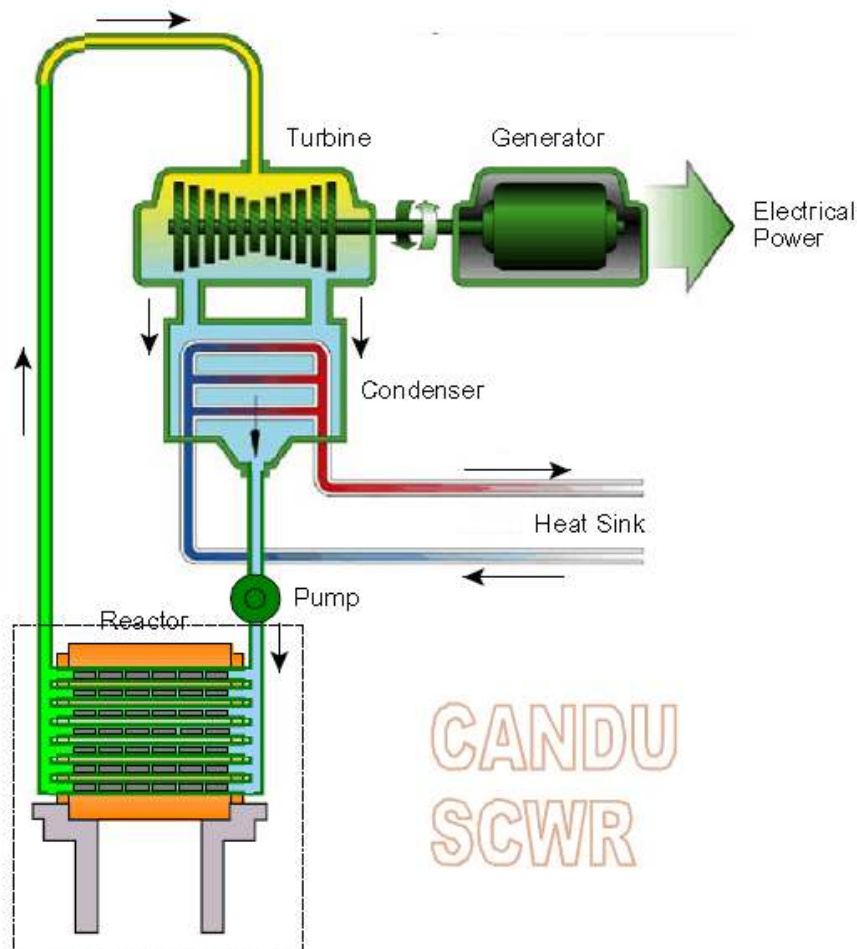


CRP on Heat Transfer Behaviour and Thermo-hydraulics Code Testing for SCWRs (1)

- **Specific Research Objectives:**
 - to establish a base of accurate data for heat transfer, pressure drop, blowdown, natural circulation and stability for conditions relevant to super-critical fluids,
 - to test analysis methods for SCWR thermo-hydraulic behaviour, and to identify code development needs.
- **Participants (12)**
 - Korea Atomic Energy Research Institute (Korea)
 - University of Wisconsin (USA)
 - China Institute for Atomic Energy (China)
 - Shanghai Jiao Tong University (China)
 - Atomic Energy of Canada, Ltd. (Canada)
 - Bhabha Atomic Research Centre (India)
 - VTT Technical Research Centre (Finland)
 - University of Pisa (Italy)
 - Gidropress (Russia)
 - Institute For Physics and Power Eng. (Russia)
 - Institute for Energy, EC-JRC (Netherlands)
 - Tsinghua University (China)
 - NRG (Netherlands) → Observer



CRP on Heat Transfer Behaviour and Thermo-hydraulics Code Testing for SCWRs (2)



- 1st RCM – July 2008
- 2nd RCM – August 2009
- 3rd RCM – August 23-27, 2010, IPPE, Obninsk, Russia
- First draft of CRP report ready after 3rd CRP
- Joint ICTP Course on Science and Technology of SCWRs (June 27 – July 1, 2011)
- Technical Meeting on Materials for SCWRs (2Q 2011)
- Additional participants
 - UOIT (Canada)
 - USA, Russia, Czech Rep. ???



CRP on Benchmarking Severe Accident Computer Codes for Heavy Water Reactor Applications (1)

- **Specific Research Objectives:**
 - to improve safety for currently operating HWRs and to facilitate more economic and safe designs for future plants
- **Participating Organizations and Computer Codes to be Used**
 - AECL (Canada): **MAAP-CANDU**
 - Shanghai Jiao Tong Univ. (SJTU, China): **RELAP5, SCDAP**
 - BARC1 (India): **RELAP5, MELCOOL**
 - BARC2 (India): **RELAP5, SCDAP, ASTEC**
 - NPCIL (India): **ATMIKA.T, CONTACT, SEVAX**
 - KAERI (Rep. of Korea): **ISSAC**
 - Politehnica Univ. of Bucharest (PUB, Romania): **RELAP5, SCDAP, COUPLE**
- **Expected Outcomes**
 - Improved understanding on HWR severe accident phenomena
 - Consensus on HWR severe accident scenario
 - Advanced information on computer code capabilities
 - Recommendations for improvements and subsequent research



CRP on Benchmarking Severe Accident Computer Codes for Heavy Water Reactor Applications (2)

- **CRP Activities:**
 - Assessment of the existing models, correlations, experiments, and computer codes
 - CANDU 6 benchmark analysis for station blackout
 - Establish criteria for major sequential failures: fuel failure, fuel channel failure, fuel channel disassembly, core collapse, calandria vessel failure and containment failure, and reactor vault failure.
 - Phase 1 : Accident initiation to fuel channel dryout
 - Phase 2 : Fuel channel dryout to core collapse
 - Phase 3 : Core collapse to calandria vessel failure
 - Phase 4 : Calandria vessel failure to containment failure
 - New experiment and Benchmark analysis for experiment
 - Documentation
- **RCM:**
 - The 1st RCM: IAEA-HQ, Vienna, Austria, February 2009
 - The 2nd RCM: NPCIL, Mumbai, India, May 2010
 - The 3rd RCM: KAERI, Daejeon, Rep. of Korea, September 2011



CRP on Development of Advanced Methodologies for Substantiation of Passive System Performance in Innovative Reactor Designs

- Objectives
 - Identify requirements for a method of reliability assessment of passive safety systems for future advanced NPPs
 - Establish a set of definitions for reliability assessment of passive safety systems
 - Identify a benchmark problem for comparison and validation of methodologies for reliability assessment of passive safety system performance
 - Benchmark select reliability assessment methodologies against selected benchmark problem
 - Compare the results and prepare recommendations
- Participants (8)
 - CNEA, Argentina
 - CEA, France
 - BARC, India
 - IGCAR, India
 - ENEA, Italy
 - University of Pisa, Italy
 - Hidropress, Russian Federation
 - Idaho State University, USA
- 1st RCM – April 2009
- 2nd RCM – March 2010



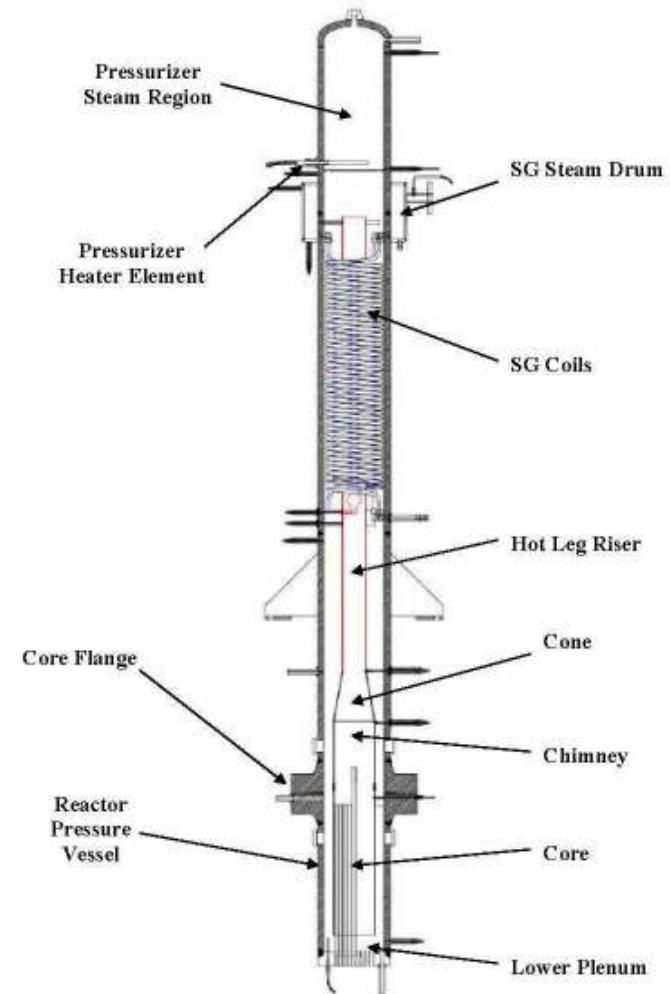
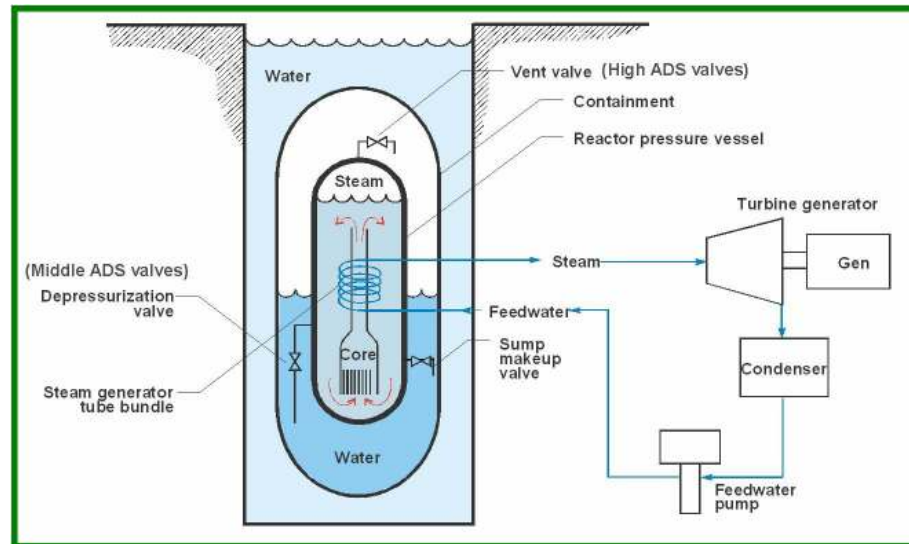
ICSP on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Containment and Primary System during Accidents (1)

- **Objectives**
 - To compare the best-estimate computer code calculations to the experimental data obtained from the integral test facility representing an integral type reactor
 - To improve the understanding of thermal-hydraulic phenomena expected to occur in normal operation and transients in an integral reactor
 - To evaluate the capability of computer codes to adequately predict the occurrence of important phenomena, and the corresponding behaviour of nuclear systems during operating, upset and accident conditions, which are represented in experiments
- **Scope**
 - A. NC with stepwise decrease in primary inventory – investigating stability with increasing 2-phase conditions (limit: liquid level at top of core)
 - B. Coupled primary system – containment response with LOFW + opening of ADS valves
- **Host: Oregon State Univ. (OSU) of USA**
- **Experimental facility description report and ICSP plan were issued**



ICSP on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Containment and Primary System during Accidents (2)

MASLWR Test Facility



ICSP on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Containment and Primary System during Accidents (3)

- Participants and Computer Codes**

No	Country	Institute	Code
1	China	China Institute of Atomic Energy	RELAP5/Mod3.2/3.3, CFD(CFX/FLUENT)
2		Shanghai Jiao Tong Univ.	SCDAP-RELAP, ATHLET
3		Tsinghua Univ.	RELAP5/Mod3.2
4	India	BARC	RELAP5/Mod3.2
5		Atomic Energy Regulatory Board	RELAP5/ASTEC
6	Italy	Univ. of Palermo	TRACE
7		Univ. of Pisa	RELAP5-3D
8	Rep. of Korea	Korea Atomic Energy Research Institute	TASS/SMR
9		Korea Institute of Nuclear Safety	MARS
10	Russian Fed.	OKB Hidropress	TRAP-97, TRAP-KS, KORSAR/GP
11		IBRAE	
12	United Kingdom	Serco	RELAP5-3D (TRACE)
13	USA	NuScale	RELAP5/Mod3.3 or N-RELAP5
14		Oregon State Univ.	RELAP5-3D
15		US Nuclear Regulatory Commission	TRACE



ICSP on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Containment and Primary System during Accidents (4)

- **First Workshop**
 - March 2010 at OSU, USA
- **Overall Schedule**
 - 1st Workshop – 16-19 March 2010
 - Distribution of ICSP Specification and Revised MASLWR Facility Description Report – 31 July 2010
 - **Double-blind calculation**
 - Conduction of characterization test (OSU) – Sep. 2010
 - Submission of double blind calculation results – Dec. 2010
 - **Conduction of ICSP tests (OSU)** – Jan. 2011
 - 2nd Workshop: 21-23 March 2011, Vienna
 - Release of real initial and boundary conditions – at 2nd workshop
 - **Blind calculation**
 - Submission of blind calculation results
 - 3rd Workshop: 8-11 November 2011
 - Release of experimental data
 - **Open calculation**
 - Submission of open calculation results
 - Production of draft document
 - 4th Workshop
 - Production of final document

ICSP on Comparison of HWR Thermal-hydraulic Code Predictions with SBLOCA Experimental Data

- **Purpose of the ICSP**
 - Improve understanding of important phenomena expected to occur in SBLOCA transients
 - Evaluate code capabilities to predict these important phenomena, their practicality and efficiency, by simulating an integrated experiment
 - Suggest necessary code improvements or new experiments to reduce uncertainties
- **Participating Organizations and Computer Codes (8)**
 - CNEA (Argentina), CATHENA
 - AECL (Canada), CATHENA
 - Tsinghua Univ. (China), CATHENA
 - AERB (India), RELAP5
 - NPCIL (India), ATMIKA
 - KINS (Rep. of Korea), MARS-KINS
 - KAERI (Rep. of Korea), CATHENA
 - CNE PROD (Romania), CATHENA
- **Selection of Experimental Cases**
 - Tests B9006 and B9802 of RD-14M SBLOCA experiments
- **Meetings**
 - 3rd Meeting: 26-28 August 2009
 - 4th Meeting: 9-12 November 2010





**4. Support near term
deployment of nuclear
programs for both emerging
and existing countries in
WCR technology
development**

Near Term Deployment

- NE Series reports
 - Technology Assessment
 - Advanced Construction Technologies
 - Efficient Water Usage in Advanced Nuclear Reactors
- Support to
 - Technical Cooperation Projects
 - Infrastructure Development Activities



Construction Technologies for Nuclear Power Plants

- NE Series Report “Construction Technologies for Nuclear Power Plants”
 - Three consultancies + One Technical Meeting
 - Goal: Assimilating global experience from a variety of recent large construction projects to provide good insight into the means of achieving a short and efficient construction schedule for future NPP construction projects.
 - Contents:
 - Comprehensive descriptions of all construction methods (conventional and advanced)
 - Advantages and disadvantages of each
 - Best practices and lessons learned
 - Report in the publication review process
- Follow-up NE Series Report: “Localization and Industrial Infrastructure Development in Support of the Construction of Nuclear Power Plants”
 - Content
 - Identify activities which could be conducted by the local labour force and the domestic industry
 - Identify trade-offs in schedule-cost considerations when using local capabilities
 - Plan the development of industrial infrastructure
 - Plan the development of human resources



Construction Technologies for Nuclear Power Plants

- Upcoming Workshops on Construction Technology
 - The Americas: Charlotte, NC, August 19-20, 2010
 - Europe & Africa: TBD, November 2010
 - Asia: TBD, early 2011

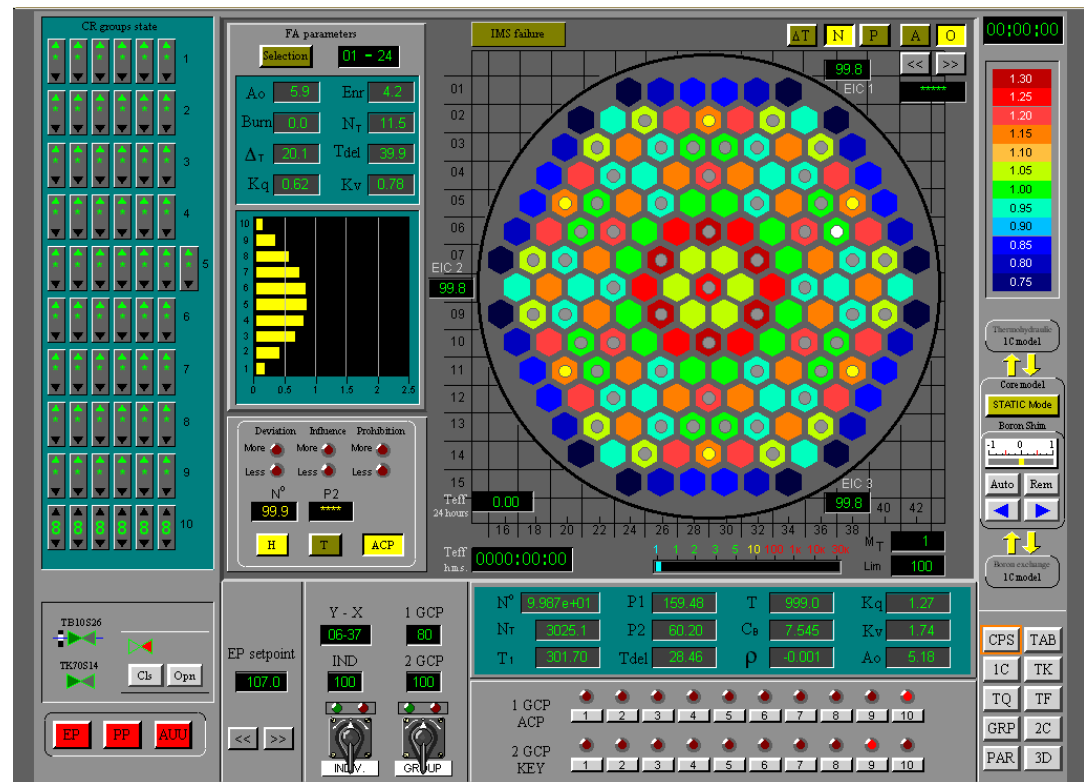




5. Provide technology training in WCR technology development

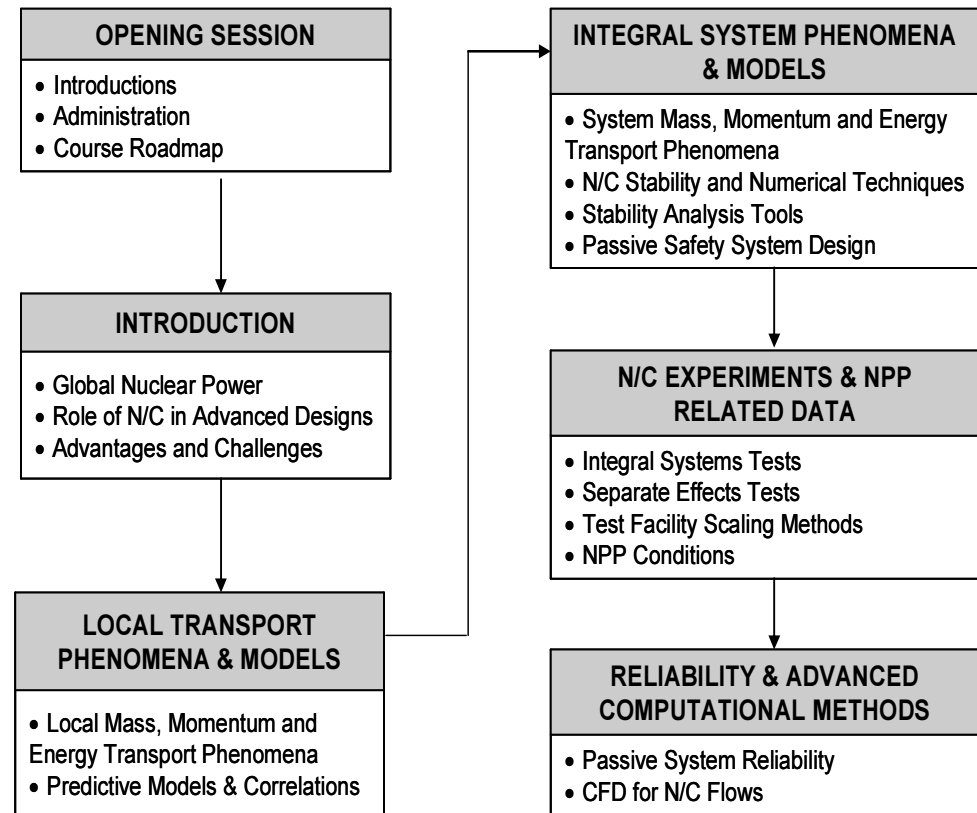
Technology Training

- Workshop on PC-based simulators of WCRs
 - WWER-1000
 - Active PWR
 - Passive PWR
 - Active BWR
 - Passive BWR
 - PHWR
 - Advanced PHWR
- Course on Natural Circulation
- Workshops on Technology Assessment
- Course on Science and Technology of SCWRs



Course on Natural Circulation

- Recent Courses
 - INL, May 2008
 - ICTP, June 2008
 - UNIP, June 2009
 - ICTP, May 2010
- Future plan
 - HEU, Harbin, China, July 2011



PC-Based Simulators

- Simulators provided free of charge to MSs – Educational purposes
- Collection of 7 simulators
 - BWR → Enhanced in 2008
 - Passive BWR → Developed in 2008-2009
 - PWR
 - Passive PWR
 - PHWR
 - Advanced PHWR
 - WWER → Manual enhanced in 2009
- 2-week workshop at ICTP, Trieste – October 12-23, 2009
- 1-week workshop at Politecnico de Milano, December 2010
- Future plans
 - Maintain and enhance the IAEA collection of simulators
 - Periodic workshops geared to University Professors
 - Workshops within the framework of TC/Infrastructure development



